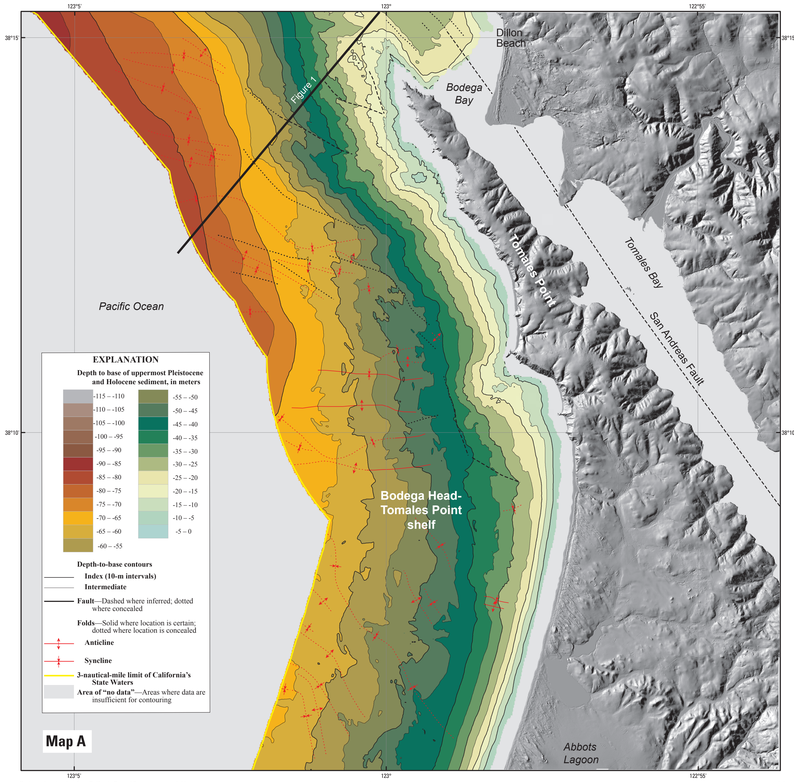
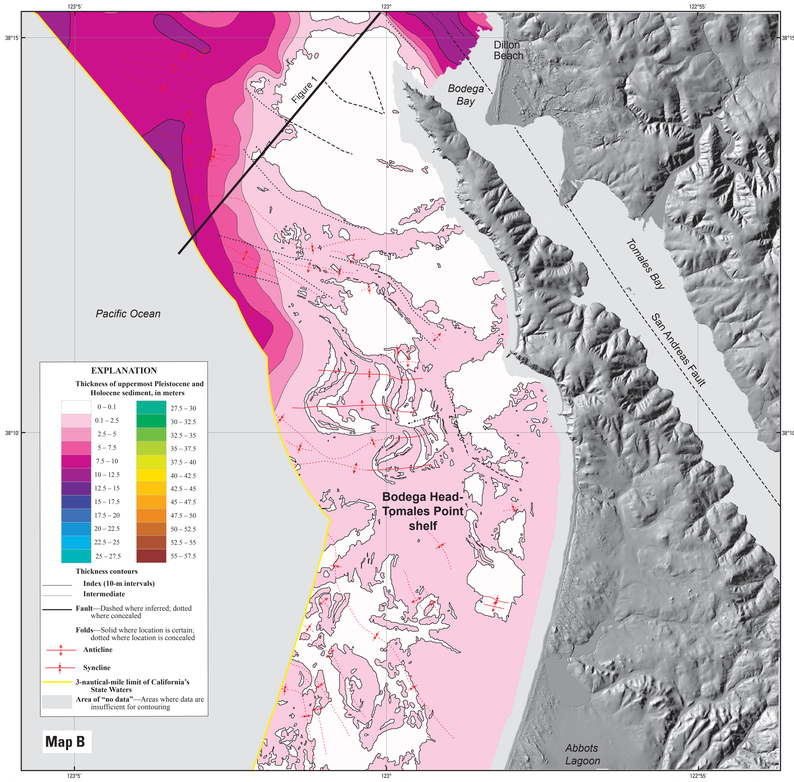
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2015–1088
Sheet 9 of 10
Pamphlet accompanies map





Onshore elevation data from California Coastal Conservancy, available at http://www.csc.noaa.gov/digitalcoast/data/coastallidar/, and from U.S. Geological Survey, National Elevation Dataset, available at http://ned.usgs.gov/. California's State Waters limit from NOAA Office of Coast Survey
Universal Transverse Mercator projection, Zone 10N

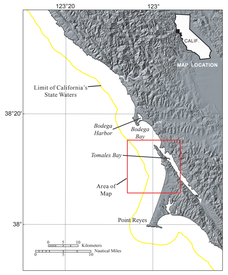
NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN DECLINATION, 2015

SCALE 1:50 000
2 1 0 2 MILES
7000 3500 0 7000 FEET
1 0.5 0 1 KILOMETER
ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Depth and thickness mapped by Samuel Y. Johnson and Steven R. Hartwell, 2012-2013
GIS database and digital cartography by Stephen R. Hartwell



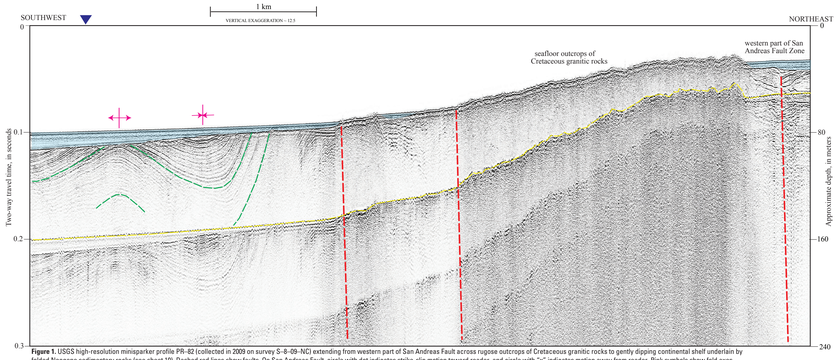
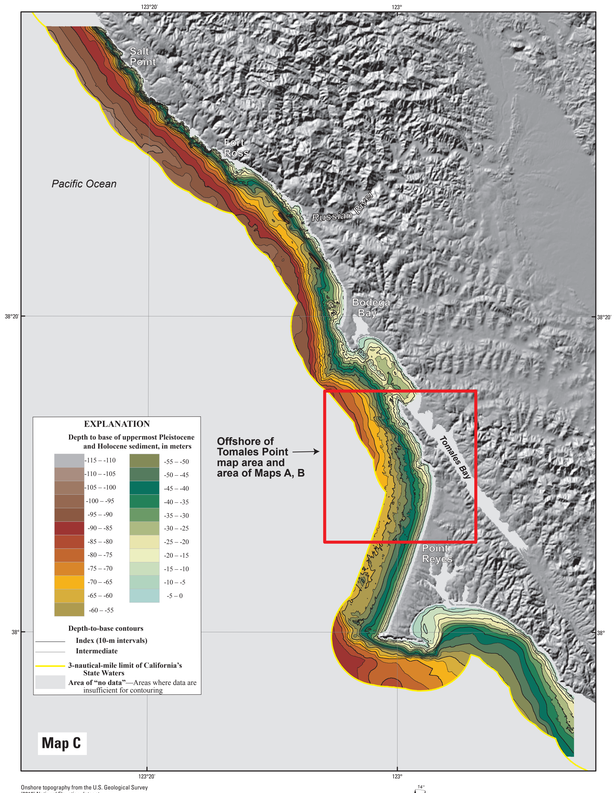
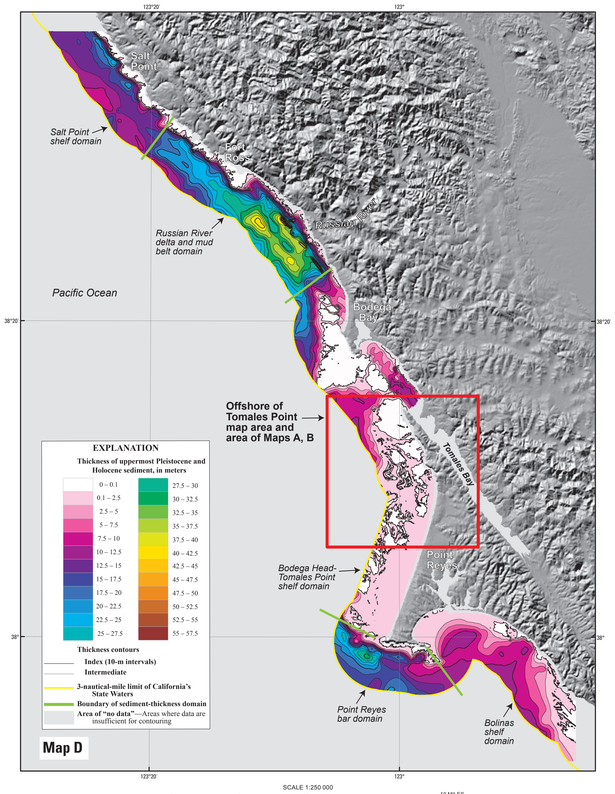
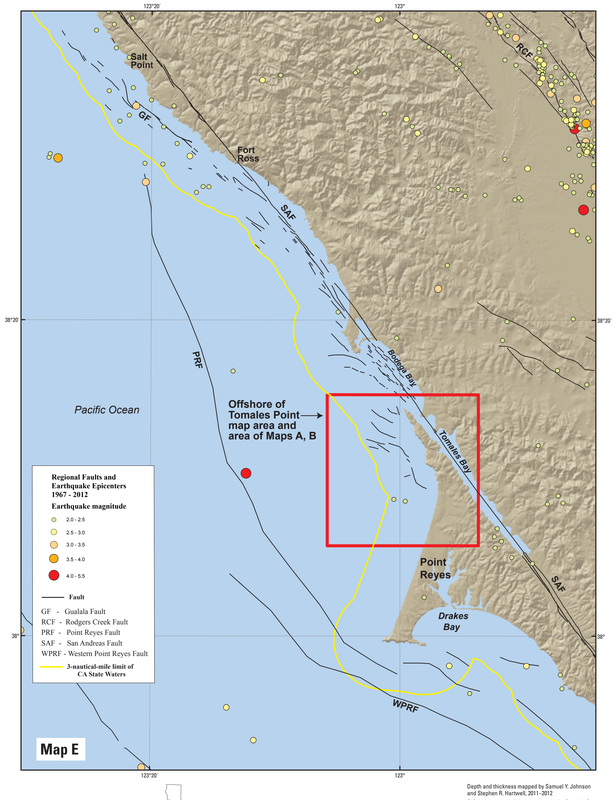


Figure 1. USGS high-resolution miniparker profile PR–82 (collected in 2009 on survey S–8–09–NC) extending from western part of San Andreas Fault across rugose outcrops of Cretaceous granitic rocks to gently dipping continental shelf underlain by folded Neogene sedimentary rocks (see sheet 10). Dashed red lines show faults. On San Andreas Fault, circle with dot indicates strike-slip motion toward reader, and circle with "x" indicates motion away from reader. Pink symbols show fold axes (diverging arrows, anticline; converging arrows, syncline). Blue shading shows thin, inferred uppermost Pleistocene and Holocene strata, deposited since the last sea-level lowstand about 21,000 years ago. Dashed green lines highlight some continuous reflections that illustrate structure (not distinctive stratigraphic markers). Dashed yellow line is seafloor multiple (echo of seafloor reflector). Purple triangle shows location of outer boundary of California's State Waters (yellow line on Map A).







SCALE 1:250 000
10 5 0 10 MILES
40 000 30 000 20 000 10 000 0 40 000 FEET
10 5 0 10 KILOMETERS
ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Depth and thickness mapped by Samuel Y. Johnson and Stephen R. Hartwell, 2011–2012
GIS database and digital cartography by Stephen R. Hartwell
Manuscript approved for publication May 4, 2015

DISCUSSION

This sheet includes maps that show the thickness and the depth to base of uppermost Pleistocene and Holocene deposits for the Offshore of Tomales Point area (Maps A, B), as well as for a larger area that extends about 115 km along the coast from Salt Point to Drakes Bay (Maps C, D) to establish a regional context. The uppermost stratigraphic unit (blue shading on the seismic-reflection profiles on sheet 8 of this report) is inferred to have been deposited during the post-Last Glacial Maximum (LGM) sea-level rise in the last 21,000 years (see, for example, Peltier and Fairbanks, 2006). The unit is commonly characterized either by "acoustic transparency" or by parallel, low-amplitude, low- to high-frequency, continuous to moderately continuous reflections (terminology from Mitchum and others, 1977). The acoustic transparency can be caused by extensive wave winnowing, which results in uniform sediment grain size and consequent lack of acoustic-impedance contrasts needed to produce seismic reflections. On the continental shelf, the contact with underlying units is a transgressive surface of erosion commonly marked by angularity, channeling, or a distinct upward change to lower amplitude, more diffuse reflections.

In the northern part of this region (Offshore of Salt Point map area), the sequence of uppermost Pleistocene and Holocene deposits, which lies above a prominent unconformity, includes a lower, older stratigraphic unit, made up of a downlapping sediment wedge that formed along the southwest flank of nearshore bedrock outcrops. Stratigraphic position, depth of occurrence, and reflection geometry suggest that this lower unit formed during the latter stages of the pre-LGM sea-level fall (about 30,000 to 21,000 years ago). Because this unit and overlying post-LGM deposits each comprise unconsolidated sediments and together overlie a prominent unconformity, our regional thickness and depth-to-base maps (Maps C, D) combine these units in this northern part of the Salt Point to Drakes Bay region.

To make these maps, water bottom and depth to base of the uppermost Pleistocene and Holocene horizons were mapped from seismic-reflection profiles (fig. 1; see also, sheet 8). The difference in the two horizons was exported for every shot point as XY coordinates (UTM zone 10) and two-way travel time (TWT). The thickness of the uppermost Pleistocene and Holocene unit (Maps B, D) was determined by applying a sound velocity of 1,600 m/sec to the TWT. The thickness points were interpolated to a preliminary continuous surface, overlaid with zero-thickness bedrock outcrops (see sheet 10), and contoured following the methods outlined in Wong and others (2012).

The thickness data points are dense along tracklines (about 1 m apart) and sparse between tracklines (1 km apart), resulting in minor contouring artifacts. To incorporate the effect of a few rapid thickness changes along faults, to remove irregularities from interpolation, and to reflect other geologic information and complexity, the resulting interpolated contours were modified. Contour modifications and regridding were repeated several times to produce the final regional sediment-thickness maps (Maps B, D). Information for the depth to base of the uppermost Pleistocene and Holocene unit (Maps A, C) was generated by adding the thickness data to water depths determined by multibeam bathymetry (see sheet 1).

The thickness of the uppermost Pleistocene and Holocene sediments in the offshore of Tomales Point map area ranges from 0 to 11 meters (Map B), and the depth to base of the unit ranges from about 10 to 85 meters (Map A). Mean sediment thickness for the map area is 2.3 m and total sediment volume is 253×106 m3 (table 7–1 in pamphlet). The thickest sediment occurs along the northern map boundary, at the mouth of Tomales Bay and at water depths of about 60 to 75 m due west of Tomales Point. These two areas are connected and represent upper and lower reaches of a now-drowned channel system that provided an outlet for Tomales Bay and small coastal drainages north of the map area during sea-level lowstand (Maps B, D).

To the south, Cretaceous granitic and Tertiary sedimentary rock crop out on the seafloor or are buried by only a thin cover (mostly less than 2.5 m) of uppermost Pleistocene and Holocene sediment. This thin cover results from a combination of factors including active uplift of the Point Reyes Peninsula (Grove and others, 2010), high wave energy, and very limited sediment supply. Tomales Point blocks southward littoral drift, and west-facing coastal watersheds on this part of the Point Reyes Peninsula are very small; therefore, much of the relatively meager sediment that is present on the shelf could be derived from erosion of local coastal bluffs and sand dunes.

Five different "domains" of sediment thickness are recognized on the regional sediment-thickness maps (table 7–1 in pamphlet; Map D), each with distinctive geologic controls: (1) The Salt Point shelf domain, located in the far northwestern part of the region has a mean sediment thickness of 11.7 m. The thickest sediment (20 to 25 m) is found where a pre-LGM, regressive, downlapping sediment wedge formed above a break in slope that is controlled by a contact between harder bedrock and softer, folded, Pleistocene strata. Sediment thinning in this domain in the outer portions of California's State Waters is the result of a relative lack of sediment supply from local watersheds, as well as a more distal Russian River source. (2) The Russian River delta and mud belt domain, located offshore of the largest sediment source on this part of the coast, has the thickest uppermost Pleistocene and Holocene sediment in the region (mean thickness, 21.1 m). The northward extension into the midshelf "mud belt" results from northward shelf-bottom currents and sediment transport (Drake and Cacchione, 1985). This domain includes a section of the San Andreas Fault Zone (Map E), which here is characterized by several releasing, right-stepping strands that bound narrow, elongate, pull-apart basins; these sedimentary basin contain the greatest thicknesses of uppermost Pleistocene and Holocene sediment (about 56 m) in the region. (3) The Bodega Head–Tomales Point shelf domain, located between Bodega Head and the Point Reyes headland, contains the least amount of sediment in the region (mean thickness of 3.4 m). The lack of sediment results from decreased "accommodation space" (note shallower depth contours on Maps A and C) and limited sediment supply. (4) The Point Reyes bar domain, located west and south of the Point Reyes headland, is a local zone of increased sediment thickness (mean thickness of 14.3 m) created by bar deposition on the more protected south flank of the Point Reyes headland during rising sea level. (5) The Bolinas shelf domain, located east and southeast of the Point Reyes headland, has a thin sediment cover (mean thickness of 5.6 m) which likely results from limited sediment accommodation space caused by tectonic uplift (water depths in this domain within California's State Waters are less than 45 m) as well as limited sediment supply and the high wave energy that is capable of reworking and transporting shelf sediment to deeper water.

Map E shows the regional pattern of major faults and earthquakes occurring between 1967 and March 2012 that have inferred or measured magnitudes of 2.0 and greater. Fault locations, which have been simplified, are compiled from interpretation of regional multi-channel industry seismic data, our mapping within California's State Waters (for example, sheet 10), (McCulloch, 1987), and the Quaternary fault and fold database (U.S. Geological Survey and California Geological Survey, 2010). Earthquake epicenters are from the Northern California Earthquake Data Center (2012), which is maintained by the U.S. Geological Survey and the University of California, Berkeley, Seismological Laboratory; all events of magnitude 2.0 and greater for the time period 1967 through March 2012 are shown. The largest earthquake in the map area (M2.1, 11/18/1978), occurred about 5 km offshore of the Point Reyes Peninsula. There has been a notable lack of microseismicity on this section of the San Andreas Fault since the great 1906 California earthquake (M7.8, 4/18/1906), thought to have nucleated on the San Andreas Fault offshore of San Francisco (fig. 1–1 in pamphlet; Bolt, 1968; Lomax, 2005).

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Local (Offshore of Tomales Point Map Area) and Regional (Offshore from Salt Point to Drakes Bay) Shallow-Subsurface Geology and Structure, California

By

Samuel Y. Johnson, Stephen R. Hartwell, Janet T. Watt, and Ray W. Sliter

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